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Semblanzas Ictiológicas
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y
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Semblanzas Ictiológicas

María Laura Habegger

Captura y marcaje de tiburones toro en el Mote Marine Lab, Sarasota, Florida, 2007

Hugo L. López y Justina Ponte Gómez

ProBiota
División Zoología Vertebrados
Museo de La Plata
FCNyM, UNLP

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Imagen de Tapa
Muestreo de peces marinos con estudiantes de Ictiología en la Universidad del sur de Florida, Howard Park, Tampa, Florida, 2009

El tiempo acaso no exista. Es posible que no pase y sólo pasemos nosotros.

Tulio Carella

Cinco minutos bastan para soñar toda una vida, así de relativo es el tiempo.

Mario Benedetti

Semblanzas Ictiológicas

A través de esta serie intentaremos conocer diferentes facetas personales de los integrantes de nuestra "comunidad".

El cuestionario, además de su principal objetivo, con sus respuestas quizás nos ayude a encontrar entre nosotros puntos en común que vayan más allá de nuestros temas de trabajo y sea un aporte a futuros estudios históricos.

Esperamos que esta iniciativa pueda ser otro nexo entre los ictiólogos de la región, ya que consideramos que el resultado general trascendería nuestras fronteras.

Hugo L. López

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Cuestionario

-**Un libro**: sigo buscándolo..
-**Una película**: casi todas de Tim Burton
-**Un CD** : Wish
-**Un artista**: muchísimos
-**Un deporte**: nadar
-**Un color**: turquesa
-**Una comida**: las milanesas de mi mama
-**Un animal**: todos
-**Una palabra**: perseverancia
-**Un número**: 7
-**Una imagen**: un mar turquesa iridiscente
-**Un lugar**: Hawaii
-**Una estación del año**: primavera
-**Un nombre**: Uma
-**Un hombre**: mi papa
-**Una mujer**: mi mama
-**Un personaje de ficción**: Stich
-**Un superhéroe**: aquellos que arriesgan su vida por otros

Cumple número 27 con sus padres en su casa de Buenos Aires, 2006

Cumple con amigos en su casa de Buenos Aires, 2008
De izquierda a derecha, su novio Martín, su mejor amigo José, María Laura y sus amigas Caro y Juli

Mejores amigas
De izquierda a derecha: Juli, María Laura y Cruz, San Telmo, 2010

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Feeding biomechanics in the Great Barracuda during ontogeny

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Keywords
bite force; functional morphology; adductor mandibulae; scaling; body size.

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Abstract

In this study we investigated bite force and functional morphology of the feeding mechanism of the great barracuda *Sphyraena barracuda* through ontogeny. Theoretical estimates of bite force at two bite points were calculated for a size series of barracuda ranging from 18 to 130 cm TL ($n = 27$) using a three-dimensional static equilibrium model. In addition, electromyography was used to determine the role of the adductor mandibulae subdivisions (A1, A2, A3) in jaw closure. All recorded subdivisions were active during jaw adduction, although onset times and activity durations differed among them. Bite force ranged from 1 to 93 N at the most anterior bite point, and from 3 to 258 N at the most posterior bite point. Mechanical advantage, in lever and posterior out lever, as well as the cross-sectional area of the majority of the adductor mandibulae subdivisions scaled with isometry; consequently bite force at both bite points also scaled with isometry. Bite force in *S. barracuda* increased in proportion to total length during ontogeny, which may be associated with a piscivorous diet throughout its life. When compared to other fishes, values of bite force in *S. barracuda* are among the lowest relative to its body size.

Introduction

Numerous factors affect resource utilization such as competition, energy consumption, risk of predation, prey availability and predator performance (Wainwright, 1991). Predator performance includes the ability of a predator to locate, capture and handle prey, all of which are influenced by morphology (Wainwright, 1988, 1991). Consequently, feeding performance is a determinant of fitness as survival is contingent upon food acquisition, and feeding performance has also been shown to affect patterns of resource use in fishes and other vertebrates (Wainwright, 1988; Hernandez & Motta, 1997; Mcbrayer, 2004; Huber *et al.*, 2005; Herrel & O'Reilly, 2006). Ontogenetic dietary shifts are common in fishes and other vertebrates (e.g. Hernandez & Motta, 1997; Ebert, 2002; Herrel & O'Reilly, 2006) which may be explained by changes in habitat or driven by changes in predator morphology and performance over ontogeny (Wainwright & Richard, 1995; Herrel & O'Reilly, 2006; Kolmann & Huber, 2009). Identifying the causal mechanisms of these dietary shifts is key to understanding the relationship between morphology, performance and ecology in vertebrate feeding.

Among various performance measures, bite force may be one of the most important due to its ecological implications and evolutionary significance affecting organismal fitness (Herrel & Gibb, 2006; Anderson, McBrayer & Herrel, 2008). For example, bite force performance in catfish *Clarias gariepinus* has been shown to vary with cranial size through ontogeny, where small individuals (< 30 cm TL) that feed on hard prey exhibit a disproportionally high bite force, while larger individuals that feed on elusive prey show lower relative values (Herrel *et al.*, 2005).

Ectotherms can grow to large adult body lengths from very small juveniles, making them a good model to quantify intraspecific scaling patterns of performance through ontogeny (Robinson & Motta, 2002; Deban & O'Reilly, 2005; Herrel & O'Reilly, 2006). Additionally, studies of feeding performance through ontogeny for top predators may offer insight into the upper limits of performance. Apex predators such as large teleosts or sharks characteristically eat large prey, and consequently are expected to exert high values of absolute bite force (Huber *et al.*, 2009). Furthermore, several studies have shown extremely high values of bite force in numerous apex predators (Erickson, Lappin & Van Vliet, 2003; Huber, Weggelaar & Motta, 2006; Wroe *et al.*, 2008; Huber *et al.*, 2009). However, the question remains whether this pattern of high bite force performance is common to apex predators.

The great barracuda *Sphyraena barracuda* is an apex predator that inhabits reefs and seagrass beds in most tropical seas around the world. Maturity occurs between two and four years of age (~55–73 cm TL) for males and

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Feeding biomechanics and theoretical calculations of bite force in bull sharks (*Carcharhinus leucas*) during ontogeny

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ABSTRACT

Evaluations of bite force, either measured directly or calculated theoretically, have been used to investigate the maximum feeding performance of a wide variety of vertebrates. However, bite force studies of fishes have focused primarily on small species due to the intractable nature of large apex predators. More massive muscles can generate higher forces and many of these fishes attain immense sizes; it is unclear how much of their biting performance is driven purely by dramatic ontogenetic increases in body size versus size-specific selection for enhanced feeding performance. In this study, we investigated biting performance and feeding biomechanics of immature and mature individuals from an ontogenetic series of an apex predator, the bull shark, *Carcharhinus leucas* (73–285 cm total length). Theoretical bite force ranged from 36 to 2128 N at the most anterior bite point, and 170 to 5914 N at the most posterior bite point over the ontogenetic series. Scaling patterns differed among the two age groups investigated; immature bull shark bite force scaled with positive allometry, whereas adult bite force scaled isometrically. When the bite force of *C. leucas* was compared to those of 12 other cartilaginous fishes, bull sharks presented the highest mass-specific bite force, greater than that of the white shark or the great hammerhead shark. A phylogenetic independent contrast analysis of anatomical and dietary variables as determinants of bite force in these 13 species indicated that the evolution of large adult bite forces in cartilaginous fishes is linked predominantly to the evolution of large body size. Multiple regressions based on mass-specific standardized contrasts suggest that the evolution of high bite forces in Chondrichthyes is further correlated with hypertrophication of the jaw adductors, increased leverage for anterior biting, and widening of the head. Lastly, we discuss the ecological significance of positive allometry in bite force as a possible "performance gain" early in the life history of *C. leucas*.

1. Introduction

Bite force, a measure of feeding performance, can have a profound effect on trophic ecology and consequently survival and fitness (Herrel and O'Reilly, 2006; Huber et al., 2006; Kolmann and Huber, 2009). Barring restrictions from gape size or prey capture performance limitation, larger absolute bite force allows a predator to ingest a wider range of foods and therefore can be considered to confer a selective advantage. It is therefore pertinent to ask how such high performance develops, both during ontogeny and on an evolutionary scale.

A straightforward way to increase bite force during development is to simply increase the overall size of the animal, as this will also increase the cross-sectional area of feeding muscles, and therefore the maximum force produced. If changes in bite force and size during ontogeny are proportional (isometry), the increase in performance can be attributed to the animal simply getting bigger. However, bite force may also scale faster (positive allometry) or slower (negative allometry) than overall growth of the body, through size-independent modifications to the anatomy and/or physiology of the feeding mechanism such as changes in jaw leverage. Determining whether performance changes are rooted simply in growth or in restructuring of the feeding mechanism during growth can help us to understand the mechanistic bases for changes in trophic structure on multiple time scales.

Unfortunately, the ecological consequences of isometric vs. allometric growth trajectories are difficult to demonstrate. Positive allometry of vertebrate bite forces has been commonly reported (Erickson et al., 2003; Herrel and Gibb, 2006; Huber et al., 2006), often in association with ontogenetic changes in diet (Wainwright, 1988; Hernandez and Motta, 1997; Erickson et al., 2003; Herrel

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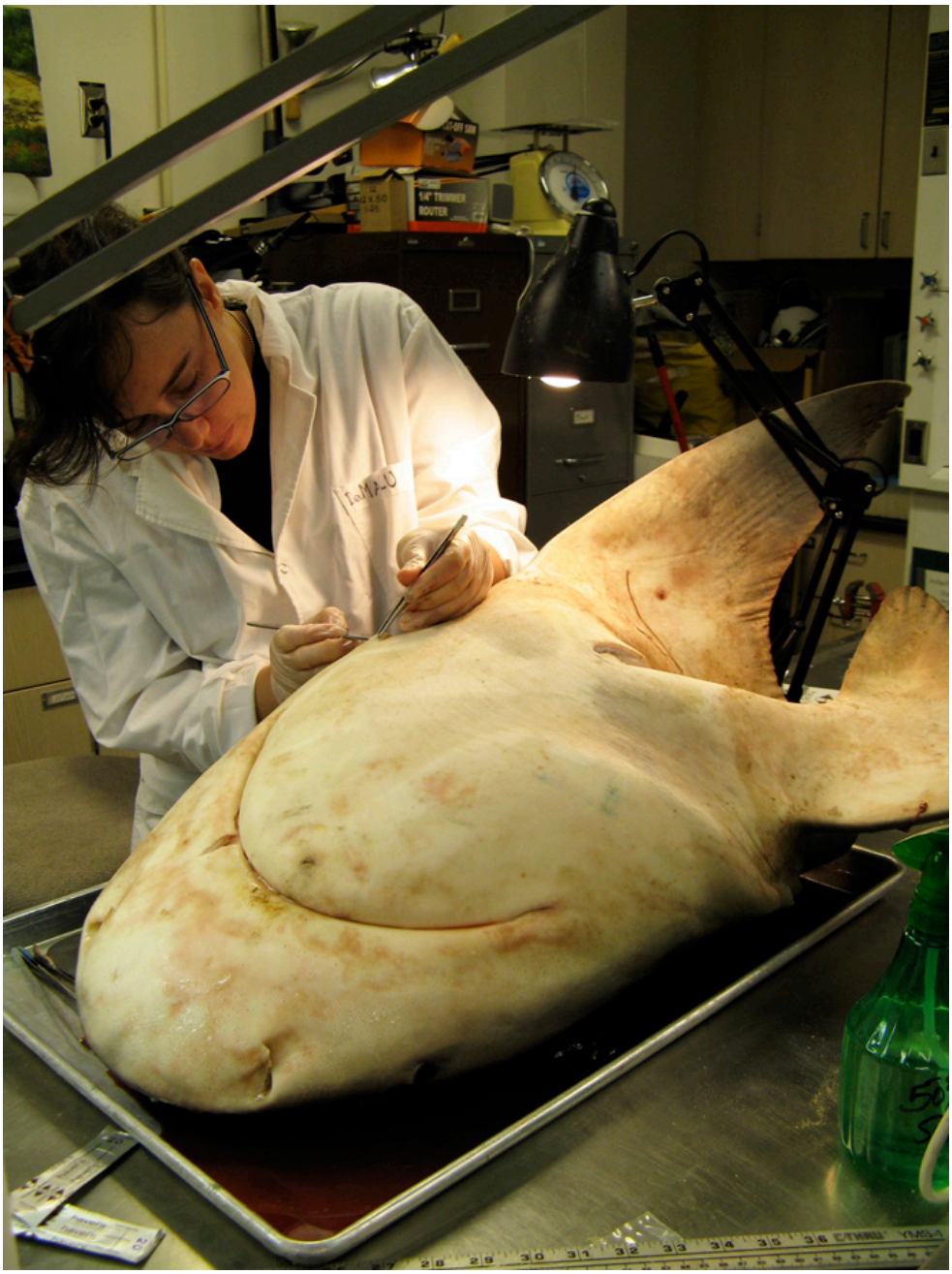
Marcaje de tiburones durante el “Clark trip” desarrollado por Mote Marine Lab, Sarasota, Florida, 2008



Disectando un tiburón toro para su tesis de maestría en el laboratorio del Dr. Motta, Universidad del Sur de Florida, 2009

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